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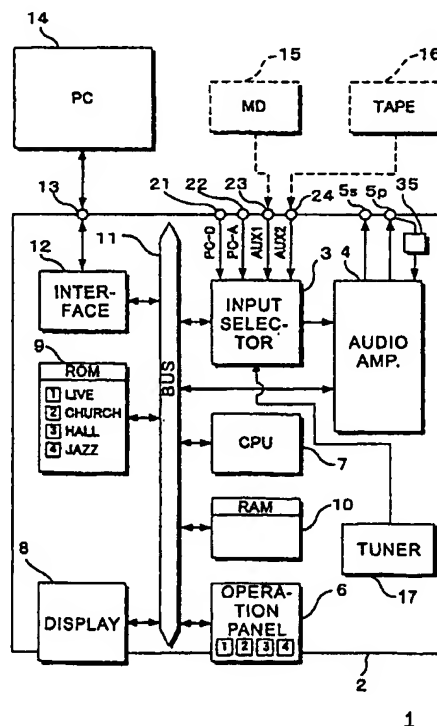
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(54) Audio system having a sound field processor

(57) An audio system comprises: a sound field processor that performs three-dimensional sound field process for a headphone to an input signal and outputs a processed signal; a loudspeaker output device that receives an input signal and outputs amplified signal to a loudspeaker; a headphone output device that receives either an input signal or the processed signal, outputs either said input signal or said processed signal as amplified signal to a headphone and is capable of being connected to said sound field processor: a headphone connector connected to said headphone output device; a headphone detector that is operably coupled to said headphone connector and detects whether a headphone is connected to said headphone connector or not; and a switch controller that is operably coupled to said headphone detector and said sound field processor, and makes said sound field processor perform said three-dimensional sound field process for a headphone and supply the processed signal to said headphone output device when said headphone detector detects a headphone.

FIG. 1



EP 1 061 774 A2

## Description

[0001] This application is based on Japanese Patent Application HEI 11-169022, filed on June 15, 1999, the entire contents of which are incorporated herein by reference.

## BACKGROUND OF THE INVENTION

### a) Field of the Invention

[0002] This invention relates to an audio system that is suitable for being used with a headphone or speakers selectively.

### b) Description of the Related Art

[0003] A system using a three-dimensional (3D) sound field processor is well known as an audio system capable of creating a 3D sound field. In the system, a sound field filtering process artificially creates a time lag and a difference in strength among sonic waves reaching ears. By that, sound sources are virtually created where real speakers are not located in order to provide 3D sound.

[0004] In the above system, when a headphone is plugged-in, a changeover from a speaker-line to a headphone-line is performed, but no change in the sound field filtering process. Therefore, a user must alter the sound field filtering process manually when a headphone is in use to get an appropriate 3D sound field effect.

## SUMMARY OF THE INVENTION

[0005] It is an object of the present invention to provide an audio system that can create appropriate sound fields automatically, without a user manipulation, when a headphone is plugged-in.

[0006] According to one aspect of the present invention, there is provided an audio system comprising: a sound field processor that performs three-dimensional sound field process for a headphone to an input signal and outputs a processed signal; a loudspeaker output device that receives an input signal and outputs amplified signal to a loudspeaker; a headphone output device that receives either an input signal or the processed signal, outputs either said input signal or said processed signal as amplified signal to a headphone and is capable of being connected to said sound field processor; a headphone connector connected to said headphone output device; a headphone detector that is operably coupled to said headphone connector and detects whether a headphone is connected to said headphone connector or not; and a switch controller that is operably coupled to said headphone detector and said sound field processor, and makes said sound field processor perform said three-dimensional sound

field process for a headphone and supply the processed signal to said headphone output device when said headphone detector detects a headphone.

[0007] According to another aspect of the present invention, there is provided an audio system comprising: a sound field processor that performs selectively either three-dimensional sound field process for a headphone or three-dimensional sound field process for a loudspeaker to an input signal and outputs a processed signal; a loudspeaker output device that receives either an input signal or the processed signal, outputs either said input signal or said processed signal as amplified signal to a loudspeaker and is capable of being connected to said sound field processor; a headphone output device that receives either an input signal or the processed signal, outputs either said input signal or said processed signal as amplified signal to a headphone and is capable of being connected to said sound field processor; a headphone connector connected to said headphone output device; a headphone detector that is operably coupled to said headphone connector and detects whether a headphone is connected to said headphone connector or not; and a switch controller that is operably coupled to said headphone detector and said sound field processor, makes said Sound field processor perform said three-dimensional sound field process for a loudspeaker and supply the processed signal to said loudspeaker output device when said headphone detector detects no headphone or makes said sound field processor perform the three-dimensional sound field process for a headphone and supply the processed signal to said headphone output device when said headphone detector detects a headphone.

## BRIEF DESCRIPTION OF THE DRAWINGS

### [0008]

FIG. 1 is a block diagram showing the structure of an audio system according to an embodiment of the invention.

FIG. 2 is a block diagram showing the structure of an audio amplifier according to the embodiment of the invention.

FIG. 3 is a diagram showing an example of a front panel of the audio system of the embodiment.

FIG. 4 is a diagram showing an example of display when a speaker mode is selected.

FIG. 5 is a diagram showing an example of display when a headphone mode is selected.

## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] FIG. 1 is a block diagram showing the structure of an audio system according to an embodiment of the invention. An audio system 1 has a receiver 2, a personal computer (PC) 14, a mini-disk (MD) player 15 and

a cassette tape deck 16.

[0010] The receiver 2 will be described next. A CPU 7 controls all the other parts of the receiver 2 and is operated by a program stored in a ROM 9. The program stored in the ROM 9 will be described later. A display 8 displays various displays under the control of the CPU 7. RAM 10 is used as a working area of the CPU 7, and various data are temporarily saved therein. An operation panel 6 has many switches or the like for various operations by a user. The CPU 7 detects the operation through the operation panel 6 and performs a necessary process based on the detected operation. An interface 12 connects the receiver 2 and the PC 14. In this embodiment, although the Universal Serial Interface (USB) is used as the interface 12, other interfaces such as IEEE1394, RS-232C or the like can be used.

[0011] An input selector 3 selects audio signals (source signals) from various audio sources. For example, the input selector 3 selects one of input lines 21 to 24. In Fig.1, the MD player 15 is connected to the input line 23, and the cassette tape deck 16 is connected to the input line 24. Moreover, the receiver 2 has a tuner 17 therein, and so the input selector 3 can select output signals of the tuner 17. The input selector 3 has a built-in analog to digital (D/A) converter, and the D/A converter converts analog signals input to the input selector 3 to digital signals. The CPU 7 processes output signals of the input selector 3 in various ways (e.g., sound-field processing), and then the audio amplifier 4 amplifies the processed output signals.

[0012] FIG. 2 is a block diagram showing the structure of the audio amplifier 4 according to the embodiment of the invention. The audio amplifier 4 has a digital to analog (D/A) converter 30, a signal selector 31, a power amplifier (an amplifier for loudspeakers) 33 and a headphone amplifier 32. An output terminal of the power amplifier 33 is connected to a speaker output 5S. An output terminal of the headphone amplifier 32 is connected to a headphone jack 5P. The source signals processed by the CPU 7 are supplied to the D/A converter wherein the signals are converted to analog signals and are output to the signal selector 31. The signal selector 31 supplies, under a control of the CPU 7, the analog output signals of the D/A converter 30 to either the headphone amplifier 32 or the power amplifier 33.

[0013] The headphone jack 5P has a headphone detector 35 for detecting whether a headphone is plugged-in or not. This headphone jack 5P can have any structures that can detect plugging of a headphone. For example, when a headphone jack 5p has a mechanical contact that makes a contact with a headphone being plugged-off and vice versa. In that case, the mechanical contact will be a headphone detector 35 at the same time, and the CPU 7 detects plugging of a headphone by detecting on/off signals of the mechanical contact. In other cases, an individual mechanical contact that can detect the plugging of a headphone may be used as a headphone detector 35, or an optical

device that can detect the plugging may be used. Moreover, the plugging of a headphone may be detected by detecting changes of impedance made by connecting a headphone to a circuit.

[0014] A sound-field processing by the CPU 7 will be described next. The CPU 7 performs 3D sound-field processes, such as a mixing process, suitable for reproducing sound from either loudspeakers or a headphone. That is, the process performed in the CPU 7 can be divided into two types; a headphone-mode process and a speaker-mode process. Programs for the processes are stored in the ROM 9.

[0015] Also, the CPU 7 outputs a signal indicating a selected mode of 3D sound-field filtering process and a signal indicating which source signal (i.e., input line) is selected by the input selector 3 to the PC 14 through the interface 12. A Program for this process is also stored in the ROM 9.

[0016] FIG. 3 is a diagram showing an example of a front panel (an operation panel) 6 of the audio system of the embodiment. Audio signal source selectors 6a1 to 6a4 enables a user to select one audio signal source from external audio sources connected to input lines 21 to 24 and the built-in tuner 17. A 3D sound-field filtering process selector 6b is a switch that enables a user to inactivate the sound-field filtering process, or to select a 3D sound-field filtering process for a headphone (a headphone mode) or a 3D sound-field filtering process for loudspeakers (a speaker mode).

[0017] A tuner registration switch 6c is for registering presets of radio channel selections. Up/down switches 6d and 6e are used for the tuner registration. A user can control master volume with a master volume 6f and turn on/off the power with a power switch 6g. The headphone jack 5p is provided, as shown in the drawing, at the lower left corner of the front panel 6.

[0018] Aforesaid display 8 is provided, as shown in Fig. 3, on the front panel 6 and has a multi-function screen 8d, input indicators 8i1 to 8i4 and a power indicator 8p.

[0019] Each of the input indicators 8i1 to 8i4 is configured next to each of the corresponding audio signal source selectors 6a1 to 6a4. In this embodiment, as shown in Fig.3, the input indicators 8i1 to 8i4 are labeled, from top to bottom; "PC", "AUX1", "AUX2", and "TUNER." Each of the input indicators 8i1 to 8i4 is illuminated when the corresponding input selector is operated, in order to indicate the selection of audio signal source.

[0020] Next, an operation of the audio system 1 according to the embodiment will be described. First, audio signals output from an audio source selected by either one of the audio signal source selectors 6a1 to 6a4 to the bus 11 via the input selector 3. Then the CPU 7 performs a 3D sound-field process to the input signals.

[0021] At this time, the CPU 7 checks the detection signal from the headphone detector 35 and performs

the 3D sound-field filtering process for loudspeakers unless a headphone is detected. At the same time, the CPU 7 makes the signal selector 31 (Fig. 2) select the power amplifier 33. By the above, the selected source signals are processed by the 3D sound-field filtering process for loudspeakers and reproduced by loudspeakers (not shown) after being amplified by the power amplifier 33.

[0022] During the process, the CPU 7 shows the sign that indicates the 3D sound-field filtering process in progress is for loudspeakers onto the multi-functional screen 8d. The sign may be text form, an icon or other graphical forms that can indicate what kind of process is in progress. Also, the CPU 7 outputs signals to the external PC 14 via the interface 12, the signals output by the CPU 7 include a signal indicating that the 3D sound-field filtering process for loudspeakers is in progress and a signal indicating what kind of source signals is selected. The PC 14 displays information about the 3D sound field filtering process based on the signals supplied from the CPU 7.

[0023] FIG. 4 is a diagram showing an example of display by the PC 14 when the speaker mode is selected. The PC 14 displays a screen, as shown in the drawing, reproducing the display on the front panel 6 on a display of the PC 14 by a software program. Various displays are shown on the screen. For example, when the PC 14 is selected as an audio source, an indicator SI saying "PC" is illuminated or changed to another color, as shown in Fig. 4. Also, in a part SA, an icon showing that loudspeakers are selected for reproduction is displayed, and in a part SB, an image showing 3D configuration of loudspeakers is displayed.

[0024] On the other hand, when a headphone is plugged into the headphone plug 5p, the CPU 7 performs the 3D sound-field filtering process for a headphone by receiving the headphone detection signal from the headphone detector 35. At the same time, the CPU 7 makes the signal selector 31 (Fig. 2) select the headphone amplifier 32. By the above, the selected source signals are processed by the 3D sound-field filtering process for a headphone and reproduced by a headphone (not shown) after being amplified by the headphone amplifier 32.

[0025] During the process, the CPU 7 shows the sign that indicates the 3D sound-field filtering process in progress is for a headphone onto the multi-functional screen 8d. The sign may be text form, an icon or other graphical forms that can indicate what kind of process is in progress. Also, the CPU 7 outputs signals to the external PC 14 via the interface 12, the signals output by the CPU 7 include a signal indicating that the 3D sound-field filtering process for a headphone is in progress and a signal indicating what kind of source signal is selected. The PC 14, similar to the above, displays information about the 3D Sound-field filtering process based on the signals supplied from the CPU 7.

[0026] FIG. 5 is a diagram showing an example of

display by the PC 14 when a headphone is plugged-in. In the part SA of the drawing, an icon showing that a headphone is selected for reproduction is displayed, and in a part SB, an image of a headphone and text "HP 3D" are displayed.

[0027] As above-described, the 3D sound-field filtering process for a headphone is performed automatically upon a connection of a headphone. In addition to that, both the operation panel 6 and the PC 14 display the information which 3D sound-field filtering process (speaker mode or headphone mode) is selected.

[0028] Moreover, according to the embodiment, the 3D sound-field filtering process can be selected manually by operating the operation panel 6. That is, the 3D sound-field filtering process for a loudspeaker can be selected when a headphone is connected. In other word, the 3D sound-field filtering process for a headphone can be selected when loudspeakers are used for reproduction. Also, the 3D sound-field filtering process can be turned off by operating the 3D sound-field filtering process selector 6b.

[0029] Although, in the embodiment, the CPU 7 performs both the 3D sound field filtering process for a loudspeaker and the 3D sound-field filtering process for a headphone, this embodiment can be used in an audio system wherein the 3D sound-field filtering process is not performed for a loudspeaker output.

[0030] In that case, the 3D sound-field filtering process is automatically performed when a headphone is plugged-in, whereas the 3D sound-field filtering process is turned off when a headphone is plugged-off. Similar display used for indicating the headphone mode in the above embodiment can be used in this case.

[0031] Moreover, supplying paths of source signals to the power amplifier 33 or to the headphone amplifier 32 are not limited to the embodiment. Various kinds of the supplying paths can be configured if there is means for the 3D sound field processing within the paths.

[0032] The present invention has been described in connection with the preferred embodiments. The invention is not limited only to the above embodiments. It will be apparent to those skilled in the art that various modifications, improvements, combinations and the like can be made.

## Claims

### 1. An audio system comprising:

- a sound field processor that performs three-dimensional sound field process for a headphone to an input signal and outputs a processed signal;
- a loudspeaker output device that receives an input signal and outputs amplified signal to a loudspeaker;
- a headphone output device that receives either an input signal or the processed signal, outputs

either said input signal or said processed signal as amplified signal to a headphone and is capable of being connected to said sound field processor;

a headphone connector connected to said 5  
headphone output device;

a headphone detector that is operably coupled to said headphone connector and detects whether a headphone is connected to said 10  
headphone connector or not; and

a switch controller that is operably coupled to said headphone detector and said sound field processor, and makes said sound field processor perform said three-dimensional sound field process for a headphone and supply the processed signal to said headphone output device 15  
when said headphone detector detects a headphone.

2. An audio system according to claim 1 further comprising a display which displays an indication showing that said three-dimensional sound field process for a headphone is selected when said switch controller makes said sound field processor perform said three-dimensional sound field process for a 25  
headphone.

3. An audio system comprising:

a sound field processor that performs selectively either three-dimensional sound field process for a headphone or three-dimensional sound field process for a loudspeaker to an input signal and outputs a processed signal; 30

a loudspeaker output device that receives 35  
either an input signal or the processed signal, outputs either said input signal or said processed signal as amplified signal to a loudspeaker and is capable of being connected to said sound field processor; 40

a headphone output device that receives either an input signal or the processed signal, outputs either said input signal or said processed signal as amplified signal to a headphone and is capable of being connected to said sound field 45  
processor;

a headphone connector connected to said headphone output device;

a headphone detector that is operably coupled to said headphone connector and detects whether a headphone is connected to said 50  
headphone connector or not; and

a switch controller that is operably coupled to said headphone detector and said sound field processor, makes said sound field processor 55  
perform said three-dimensional sound field process for a loudspeaker and supply the processed signal to said loudspeaker output device

when said headphone detector detects no headphone or makes said sound field processor perform the three-dimensional sound field process for a headphone and supply the processed signal to said headphone output device when said headphone detector detects a headphone.

4. An audio system according to claim 3 further comprising a display which displays an indication showing that said three-dimensional sound field process for a headphone is selected when said switch controller makes said sound field processor perform said three-dimensional sound field process for a 10  
headphone.

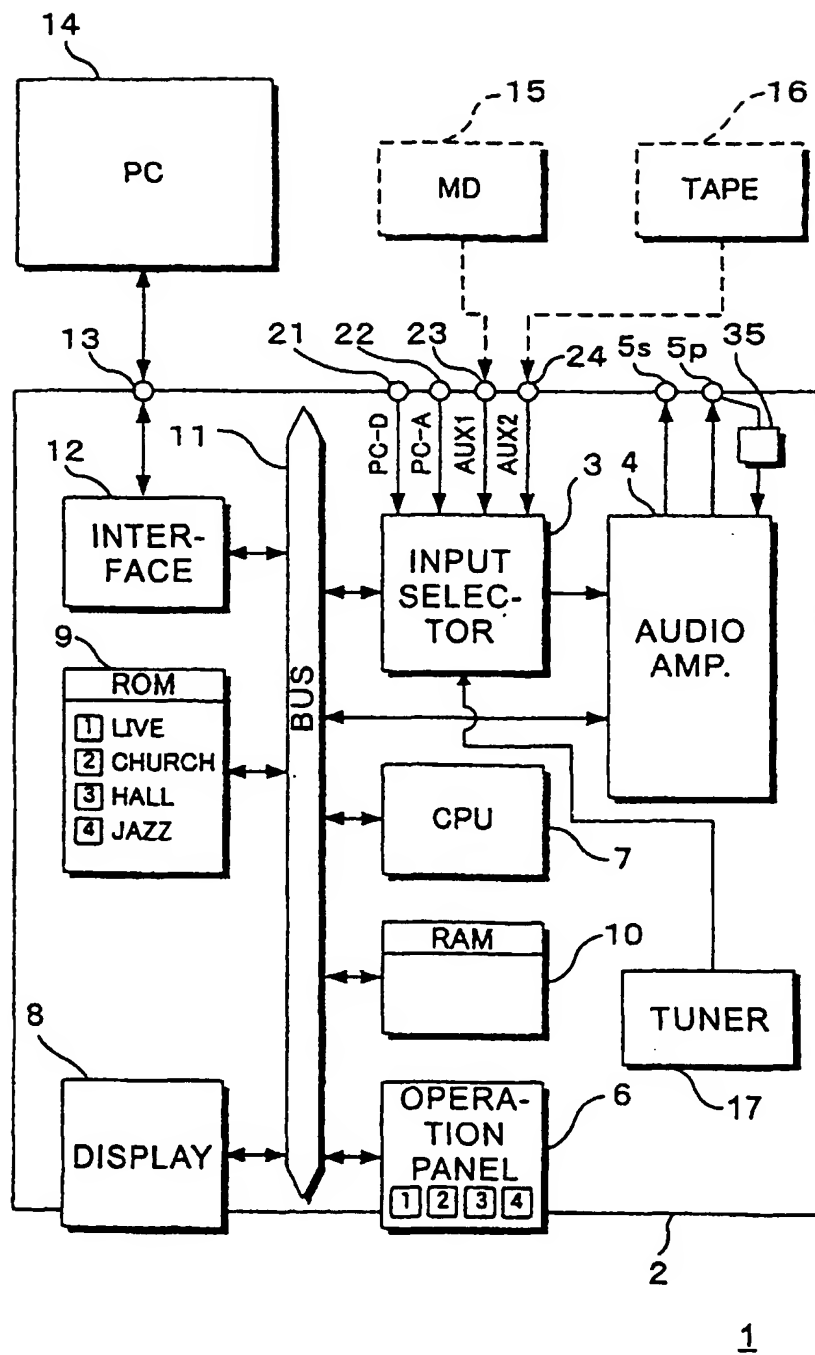
5. An audio system according to claim 3 further comprising;

an interface to which an external device can be connected; and  
an indicating signal output device that outputs an indicating signal to an external device through said interface, the indicating signal indicating said three-dimensional sound field process for a headphone is selected when said switch controller makes said sound field processor perform said three-dimensional sound field process for a headphone.

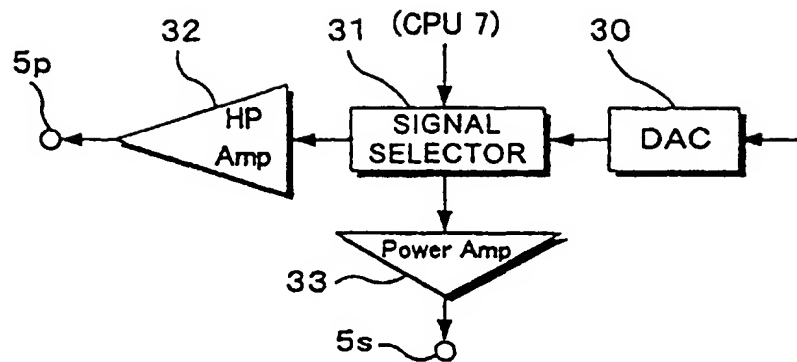
6. An audio system according to claim 4 further comprising;

an interface to which an external device can be connected; and  
an indicating signal output device that outputs an indicating signal to an external device through said interface, the indicating signal indicating said three-dimensional sound field process for a headphone is selected when said switch controller makes said sound field processor perform said three-dimensional sound field process for a headphone.

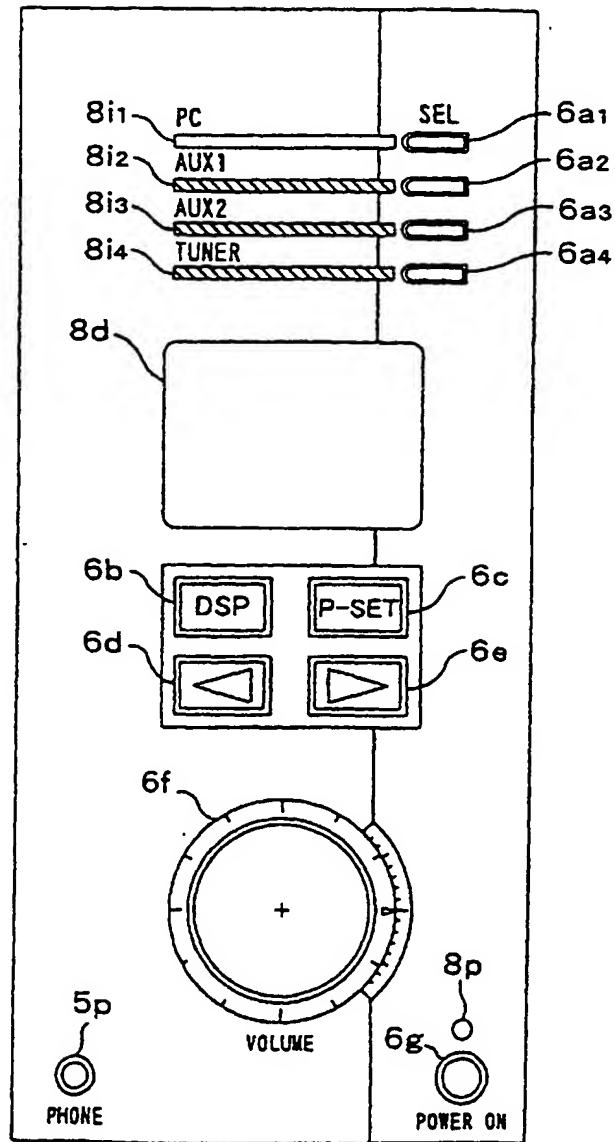
**FIG. 1**



**FIG. 2**

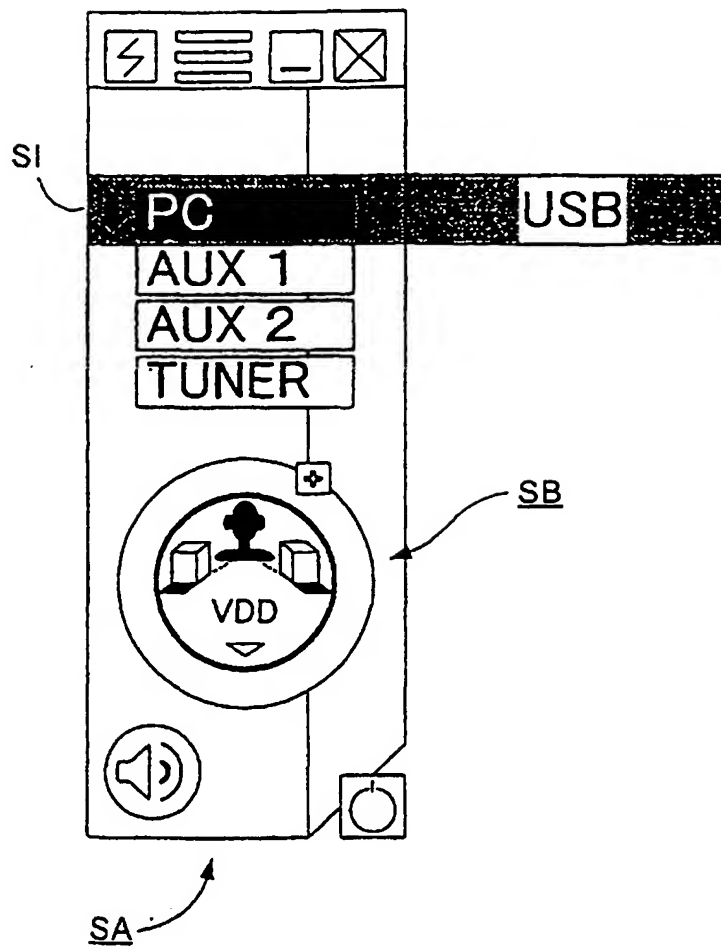


**FIG. 3**





**FIG. 4**



**FIG. 5**

